

RECYCLABILITY EVALUATION OF WASTE TABLETS

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Abstract: Unlike other e-waste, generation of waste tablets is more recent, and very little is known about its composition and recycling routes. The determination of the recyclability of an e-waste depends on its composition, in which the presence of valuable or critical materials, as well as their concentration in relation to the total weight, defines the profit estimate that can be obtained through recycling. Thus, the aim of this paper was to determine the gravimetric composition and concentration of the metals present in the printed circuit boards (PCB) of waste tablets. PCB represented 6.31% wt. of tablets studied. The concentration of copper (25% wt.) is economically viable from the point of view of recycling, and the presence of gold increases the economic potential, as the tablets are part of the group of new e-waste that create greater interest in recycling, along with smartphones.

Key words: waste tablets, recyclability, e-waste, composition.

1. Introduction

Introduced in Brazil as of 2010, tablet sales volume in the country increased 800% from 2010 to 2014 [1], becoming rapidly obsolete as also observed for other Technology Information and Communication (TIC) equipment. The high volume of tablet sales in replacement of notebooks is possibly due to increased mobility, adequate screen size, resolution, and internet access [2, 3]. Thus, Martinho et al. [2] pointed out that the volume of tablet sales was approximately 248 million units in 2015.

Although the volume of tablets that have reached the end of their useful life is not as expressive as that of desktops, smartphones, and notebooks, their representativeness in the world scenario calls attention to the need for their disposal management. The environmental liability that will grow in the coming years, along with other types of e-waste, is notable.

The proper management of waste tablets depends on the knowledge of its composition, for which physical processing is usually used to determine the gravimetric composition and characterization process usually adopted the combination of mechanical processes with chemical and/or thermal processes due to the complex composition containing metal, alloy, plastics, PCB, among others and the e-waste heterogeneity. In order to identify all the elements present, the use of different acids can also be adopted. For the chemical leaching, it is perceived that aqua regia is constantly used, since it solubilizes precious metals like gold, silver and palladium at the same time, in addition to other metals such as copper in leachate purity above 96% [4, 5].

2. Materials and Methods

Stage 1 - Determination of the gravimetric composition of waste tablets

25 waste tablets of different models were manual dismantling and weighted. The components were classified into 5 categories: batteries, printed circuit boards (PCB), screens of varied sizes (7.1 "to 9"), metal and / or plastic housing, chargers and cables.

Stage 2 - Characterization of the printed circuit boards of waste tablets

Tablet PCBs were characterized by mechanical processing, acid digestion and loss-on-ignition. The mechanical processing involved the reduction of the size and the comminution using vibratory disk mill. After comminution, the samples were solubilized under acid attack to determine the concentration of metals. For this purpose, a solution of aqua regia in the proportion (%v/v) of 1 HNO₃:3 HCl, and the experiment was performed in triplicate. In this stage, the S/L ratio of 1g of sample to 20 mL of aqua regia was used. Loss-on-ignition was performed at 800°C during 1h using a muffin in order to determine inorganic fraction.

For quantitative determination of the metals present in tablets PCBs, aliquots were analyzed in PerkinElmer's Inductively Coupled Plasma Optical Emission Spectrometry (ICP OES) model OPTIMA 800.

3. Results and Discussion

Stage 1 - Determination of the gravimetric composition of waste tablets

The average weight of the tablets, including charger and cables, was 495.58g, the screen representing almost 1/4 of their total weight, while the PCI represents approximately 6.31%.

Stage 2 - Characterization of the printed circuit boards of waste tablets

The characterization results obtained were: 31%w/w of polymers, 33%w/w of inorganic material and 36%w/w of metals. The percentage distribution of materials and/or metals for the group of new WEEE (smartphones, tablets and notebooks) is reported in different papers [6, 7, 8]. From the point of view of recycling, tablets have a higher content of valuable metals than notebooks (for a given weight), which exist on both the screen and the PDBs, according to Tesfaye et al. (2017). While smartphones are more similar to notebooks due to manufacturing, the concentration of copper is greater in tablets than in smartphones [6].

The concentration of copper in tablet PCBs represented up to 25% of the mass of the PCB, but the quantity of gold (0.01%) has the greater recycling potential in tablets. A study by Cucchiella et al. [6] showed that copper is the second material in a top ten material list with 13.9% profit potential, behind only gold that represented 50.4% profit potential. Additionally, copper represents a viable alternative for secondary source of metals and also prevents intensive exploitation of the natural reserves of metals [9].

Tesfaye et al. [3] suggested that, despite being a relatively new group of products, e-waste from TIC equipment is likely to be the most profitable source of recycling, noting that the same processes for recovering components with market value can also be applied to smartphones, notebooks, and tablets.

4. Conclusions

The printed circuit boards represent 6.3% wt. of the waste tablets, the most valuable component being recycled, although the gravimetric composition has shown that the screens, which have a lower recycling potential, represent 25% wt. On the other hand, the characterization of the printed circuit boards of tablets showed that 36% wt. correspond to the metals, 25% wt. of copper, besides the presence of gold (0.01%), the two metals being more profitable in the recycling. The similarity of the composition of the PCBs of tablets with laptops and smartphones demonstrates that it is economically feasible to group them in order to recover gold, and in the background, of copper, since not all PCIs have gold in their composition.

Acknowledgements

This work has been sponsored by Fundação de Amparo à Pesquisa e Inovação do Espírito Santo (FAPES), Espírito Santo, Brazil (Process nº 68781369/2014).

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